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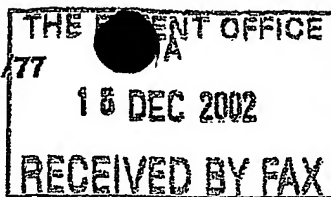
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1777

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1. Your reference

P33024-TS/IL/KJO

2. Patent application number

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0229354.6

18 DEC 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*The Robert Gordon University
Schoolhill
Aberdeen
AB10 1FRPatents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

"Video Encoding"

5. Name of your agent *(if you have one)**"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)*Murgitroyd & Company
Scotland House
165-169 Scotland Street
Glasgow
G5 8PLPatents ADP number *(if you know it)*

1198015

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country

Priority application number
*(if you know it)*Date of filing
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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing
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Yes

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11. I/We request the grant of a patent on the basis of this application.
 Signature Murgitroyd & Company Date 18 December 2002
 Murgitroyd & Company

12. Name and daytime telephone number of person to contact in the United Kingdom
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1 Video Encoding

2

3 The invention relates to video encoders and in
4 particular to reducing the computational complexity
5 when encoding video.

6

7 Video encoders and decoders (CODECs) based on video
8 encoding standards such as H263 and MPEG-4 are well
9 known in the art of video compression.

10

11 The development of these standards has led to the
12 ability to send video over much smaller bandwidths
13 with only a minor reduction in quality. However,
14 decoding and, more specifically, encoding, requires
15 a significant amount of computational processing
16 resources. For mobile devices, such as personal
17 digital assistants (PDA's) or mobile telephones,
18 power usage is closely related to processor
19 utilisation and therefore relates to the life of the
20 battery charge. It is obviously desirable to reduce
21 the amount of processing in mobile devices to

1 the amount of processing in mobile devices to
2 increase the operable time of the device for each
3 battery charge. In general-purpose personal
4 computers, CODECs must share processing resources
5 with other applications. This has contributed to the
6 drive to reduce processing utilisation, and
7 therefore power drain, without compromising viewing
8 quality.

9
10 In many video applications, such as tele-
11 conferences, the majority of the area captured by
12 the camera is static. In these cases, power
13 resources or processor resources are being used
14 unnecessarily to encode areas which have not changed
15 significantly from a reference video frame.

16
17 The typical steps required to process the pictures
18 in a video by an encoder such as one that is H263 or
19 MPEG-4 Simple Profile compatible, are described as
20 an example.

21
22 The first step requires that reference pictures be
23 selected for the current picture. These reference
24 pictures are divided into non-overlapping
25 macroblocks. Each macroblock comprises four
26 luminance blocks and two chrominance blocks, each
27 block comprising 8 pixels by 8 pixels.

28
29 It is well known that the steps in the encoding
30 process that typically require the greatest
31 computational time are the motion estimation, the

1 forward discrete cosine transform (FDCT) and the
2 inverse discrete cosine transform (IDCT).

3
4 The motion estimation step looks for similarities
5 between the current picture and one or more
6 reference pictures. For each macroblock in the
7 current picture, a search is carried out to identify
8 a prediction macroblock in the reference picture
9 which best matches the current macroblock in the
10 current picture. The prediction macroblock is
11 identified by a motion vector (MV) which indicates a
12 distance offset from the current macroblock. The
13 prediction macroblock is then subtracted from the
14 current macroblock to form a prediction error (PE)
15 macroblock. This PE macroblock is then discrete
16 cosine transformed, which transforms an image from
17 the spatial domain to the frequency domain and
18 outputs a matrix of coefficients relating to the
19 spectral sub-bands. For most pictures much of the
20 signal energy is at low frequencies, which is what
21 the human eye is most sensitive to. The formed DCT
22 matrix is then quantised which involves dividing the
23 DCT coefficients by a quantizer value and then
24 rounding to the nearest integer. This has the effect
25 of reducing many of the higher frequency
26 coefficients to zeros and is the step that will
27 cause distortion to the image. Typically, the higher
28 the quantizer step size, the poorer the quality of
29 the image. The values from the matrix after the
30 quantizer step are then re-ordered by "zigzag"
31 scanning. This involves reading the values from the
32 top left-hand corner of the matrix diagonally back

1 and forward down to the bottom right-hand corner of
2 the matrix. This tends to group the zeros together
3 which allows the stream to be efficiently run-level
4 encoded (RLE) before eventually being converted into
5 a bitstream by entropy encoding. Other "header" data
6 is usually added at this point.

7
8 If the MV is equal to zero and the quantised DCT
9 coefficients are all equal to zero then there is no
10 need to include encoded data for the macroblock in
11 the encoded bitstream. Instead, header information
12 is included to indicate that the macroblock has been
13 "skipped".

14
15 US 6,192,148 discloses a method for predicting
16 whether a macroblock should be skipped prior to the
17 DCT steps of the encoding process. This method
18 decides whether to complete the steps after the
19 motion estimation if the MV has been returned as
20 zero, the mean absolute difference of the luminance
21 values of the macroblock is less than a first
22 threshold and the mean absolute difference of the
23 chrominance values of the macroblock is less than a
24 second threshold.

25
26 For the total encoding process the motion estimation
27 and the FDCT and IDCT are typically the most
28 processor intensive. The prior art only predicts
29 skipped blocks after the step of motion estimation
30 and therefore still contains a step in the process
31 that can be considered processor intensive.

32

1 The present invention discloses a method to predict
2 skipped macroblocks that requires no motion
3 estimation or DCT steps.

4
5 According to one aspect, the invention provides a
6 method of encoding video pictures comprising the
7 steps of:

8 dividing the picture into regions;
9 predicting whether each region requires
10 processing through further steps by comparing each
11 region with a reference region. Hence, the invention
12 avoids unnecessary use of resources by avoiding
13 processor intensive operations where possible.

14
15 The further steps preferably include motion
16 estimation and/or discrete cosine transform steps.

17
18 A region is preferably a non-overlapping macroblock.

19
20 A macroblock is preferably a sixteen by sixteen
21 matrix of pixels.

22
23 Further preferably, a reference region is one or
24 more macroblocks in the same position in the video
25 picture but from one or more different reference
26 time frames as selected by other encoding steps.

27
28 Preferably, the step of predicting includes two or
29 more sub-steps.

30
31 Preferably, the sub-steps of the predicting step are
32 calculations.

1
2 Preferably, one of the calculations is whether an
3 estimate of the energy of some or all pixel values
4 of the macroblock, optionally divided by the
5 quantizer step size, is less than a predetermined
6 threshold value.

7
8 Alternatively or further preferably, one of the
9 calculations is whether an estimate of the values of
10 certain discrete cosine transform coefficients for
11 one or more sub-blocks of the macroblock, is less
12 than a second threshold value.

13
14 Further preferably, the method of encoding pictures
15 may be performed by a computer program embodied on a
16 computer usable medium.

17
18 Further preferably, the method of encoding pictures
19 may be performed by electronic circuitry.

20
21 The estimate of the values of certain discrete
22 cosine transform coefficients may involve:
23 dividing the sub-blocks into four equal regions;
24 calculating the sum of absolute differences of the
25 residual pixel values for each region of the sub-
26 block, where the residual pixel value is the
27 corresponding reference pixel luminance value
28 subtracted from the current pixel luminance value;
29 estimating the low frequency discrete cosine
30 transform coefficients for each region of the sub-
31 blocks, such that:

7

$$Y_{01} = \text{abs}(A + C - B - D)$$

$$Y_{10} = \text{abs}(A + B - C - D)$$

$$Y_{11} = \text{abs}(A + D - B - C)$$

1
2 where Y_{01} , Y_{10} and Y_{11} represent the estimations
3 of three low frequency discrete cosine transform
4 coefficients and A, B, C and D represent the sum of
5 absolute differences of each of the regions of the
6 sub-block where A is the top left hand corner, B is
7 the top right hand corner, C is the bottom left hand
8 corner and D is the bottom right hand corner; and
9 selecting the maximum value of the estimate of
10 the discrete cosine transform coefficients from all
11 the estimates calculated.

12
13 The invention will now be described, by way of
14 example, with reference to the figures of the
15 drawings in which:

16
17 Figure 1 shows a flow diagram of a video picture
18 encoding process.

19
20 Figure 2 shows a flow diagram of a macroblock
21 encoding process

22
23 Figure 3 shows a flow diagram of a prediction
24 decision process

25
26 With reference to Figure.1, a first step 102 reads a
27 picture frame in a video sequence and divides it
28 into non-overlapping macroblocks (MBs). Each MB
29 comprises four luminance blocks and two chrominance

1 blocks, each block comprising 8 pixels by 8 pixels.

2 Step 104 encodes the MB as shown in Figure 2.

3

4 With reference to Figure 2, a MB encoding process is
5 shown 104, where a decision step 202 is performed
6 before any other step.

7

8 The current H263 encoding process currently teaches
9 that each MB in the video encoding process typically
10 goes through the steps 204 to 226 or equivalent
11 processes, in the order shown in Figure 2 or in a
12 different order. Motion estimation step 204
13 identifies one or more prediction MB(s) each of
14 which is defined by a MV indicating a distance
15 offset from the current MB and a selection of a
16 reference picture. Motion compensation step 206
17 subtracts the prediction MB from the current MB to
18 form a Prediction Error (PE) MB. If the value of MV
19 requires to be encoded (step 208), then MV is
20 entropy encoded (step 210) optionally with reference
21 to a predicted MV.

22

23 Each block of the PE MB is then forward discrete
24 cosine transformed (FDCT) 212 which outputs a block
25 of coefficients representing the spectral sub-bands
26 of each of the PE blocks. The coefficients of the
27 FDCT block are then quantized (for example through
28 division by a quantizer step size) 214 and then
29 rounded to the nearest integer. This has the effect
30 of reducing many of the coefficients to zero. If
31 there are any non-zero quantized coefficients

1 (Qcoeff) 216 then the resulting block is entropy
2 encoded by steps 218 to 222.

3 In order to form a reconstructed picture for further
4 predictions, the quantized coefficients (QCoeff) are
5 re-scaled (for example by multiplication by a
6 quantizer step size) 224 and transformed with an
7 inverse discrete cosine transform (IDCT) 226. After
8 the IDCT the reconstructed PE MB is added to the
9 reference MB and stored for further prediction.

10
11 The decision step 228 looks at the output of the
12 prior processes and if the MV is equal to zero and
13 all the Qcoeffs are zero then the encoded
14 information is not written to the bitstream but a
15 skip MB indication is written instead. This means
16 that all the processing time that has been used to
17 encode the MB has not been necessary because the MB
18 is regarded as similar to or the same as the
19 previous MB.

20
21 Decision step 202 predicts whether the current MB is
22 likely to be skipped, that is that after the process
23 steps 202 - 226, the MB is not coded but a skip
24 indication is written instead. If the Decision step
25 202 does predict that the MB would be skipped the MB
26 is not passed on to the step 204 and the following
27 process steps but skip information is passed
28 directly to step 232.

29
30 With reference to Figure 3, a flow diagram is shown
31 of the decision to skip the MB 202.

1 MBs that are skipped have zero MV and QCoeff. Both
2 of these conditions are likely to be met if there is
3 a strong similarity between the current MB and the
4 same MB position in the reference frame. The energy
5 of a residual MB formed by subtracting the reference
6 MB, without motion compensation, from the current MB
7 is approximated by the sum of absolute differences
8 for the luminance part of the MB with zero
9 displacement ($SADO_{MB}$) given by:

$$10 \quad SADO_{MB} = \sum_{i=0}^{15} \sum_{j=0}^{15} |C_C(i,j) - C_P(i,j)| \quad \text{Equation 1}$$

11 $C_C(i,j)$ and $C_P(i,j)$ are luminance samples from an MB
12 in the current frame and in the same position in
13 the reference frame, respectively.

14

15 The relationship between $SADO_{MB}$ and the probability
16 that the MB will be skipped also depends on the
17 quantizer step size since a higher step size
18 typically results in an increased proportion of
19 skipped MBs.

20 A comparison of the calculation $SADO_{MB}$ (optionally
21 divided by the quantizer step size (Q)) 302 to a
22 first threshold value gives a first comparison step
23 304. If the calculated value is greater than a first
24 threshold value then the MB is passed to step 204
25 and enters a normal encoding process. If the
26 calculated value is less than a first threshold
27 value then a second calculation is performed 306.

28

29 Step 306 performs additional calculations on the
30 residual MB. Each 8x8 luminance block is divided
31 into four 4x4 blocks. A, B, C and D (Equation 2) are

11

1 the SAD values of each 4x4 block and $R(i, j)$ are the
2 residual pixel values without motion compensation.

$$3 \quad A = \sum_{i=0}^3 \sum_{j=0}^3 |R(i, j)| \quad B = \sum_{i=0}^3 \sum_{j=3}^7 |R(i, j)|$$

Equation 2

$$6 \quad C = \sum_{i=4}^7 \sum_{j=0}^3 |R(i, j)| \quad D = \sum_{i=4}^7 \sum_{j=4}^7 |R(i, j)|$$

7
8 Y_{01} , Y_{10} and Y_{11} (Equation 3) provide a low-complexity
9 estimate of the magnitudes of the three low
10 frequency DCT coefficients $\text{coeff}(0,1)$, $\text{coeff}(1,0)$
11 and $\text{coeff}(1,1)$ respectively. If any of these
12 coefficients is large then there is a high
13 probability that the MB should not be skipped.
14 $Y_{4 \times 4 \text{ block}}$ (Equation 4) is therefore used to predict
15 whether each block may be skipped. The maximum for
16 the luminance part of a macroblock is calculated
17 using Equation 5.

18

$$19 \quad Y_{01} = \text{abs}(A + C - B - D) \quad Y_{10} = \text{abs}(A + B - C - D)$$

$$20 \quad Y_{11} = \text{abs}(A + D - B - C)$$

Equation 3

22

$$23 \quad Y_{4 \times 4 \text{ block}} = \text{MAX}(Y_{01}, Y_{10}, Y_{11})$$

Equation 4

25

$$26 \quad Y_{4 \times 4 \text{ max}} = \text{MAX}(Y_{4 \times 4 \text{ block1}}, Y_{4 \times 4 \text{ block2}}, Y_{4 \times 4 \text{ block3}}, Y_{4 \times 4 \text{ block4}})$$

Equation 5

28

1 The calculated value of $Y4 \times 4_{max}$ is compared with a
2 second threshold 308. If the calculated value is
3 less than a second threshold then the MB is skipped
4 and the next step in the process is 232. If the
5 calculated value is greater than a second threshold
6 then the MB is passed to step 204 and the subsequent
7 steps for encoding.

8

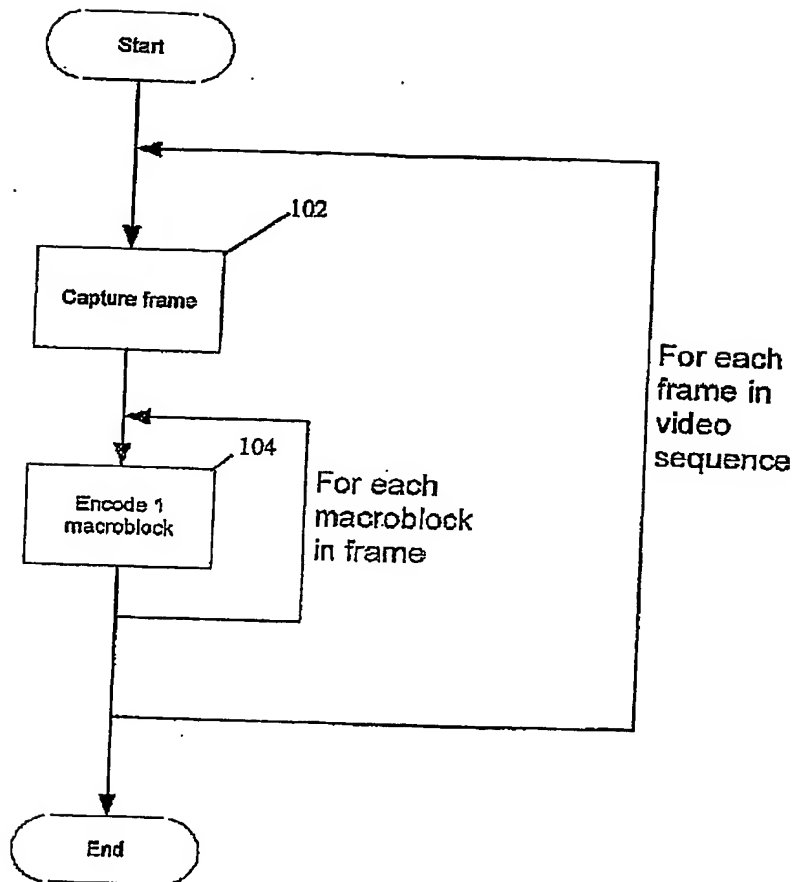
9 These steps typically have very little impact on
10 computational complexity. $SAD0_{MB}$ is normally computed
11 in the first step of any motion estimation algorithm
12 and so there is no extra calculation required.
13 Furthermore, the SAD values of each 4×4 block (A, B,
14 C and D in Equation 2) may be calculated without
15 penalty if $SAD0_{MB}$ is calculated by adding together
16 the values of SAD for each 4×4 -sample sub-block in
17 the MB.

18

19 The additional computational requirements of the
20 classification algorithm are the operations in
21 Equations 3, 4 and 5 and these are typically not
22 computationally intensive.

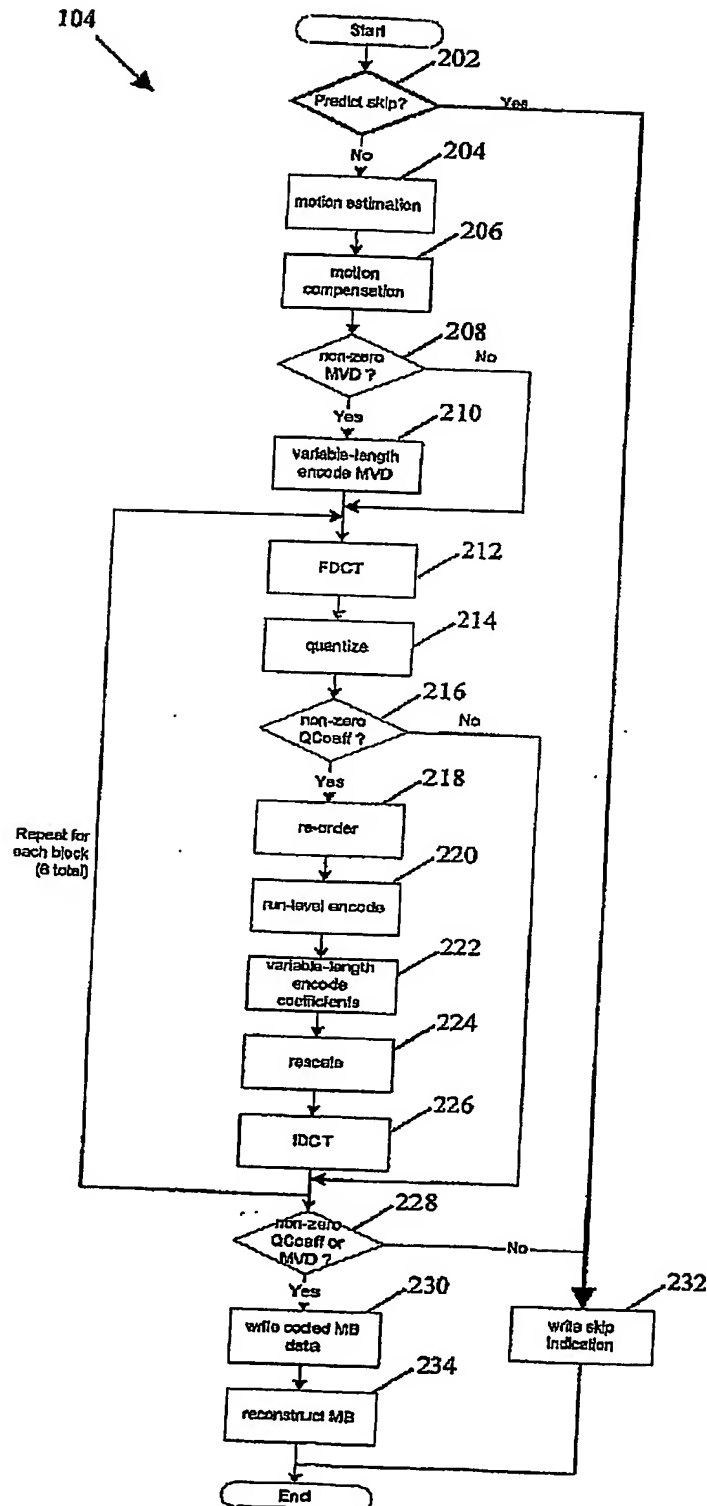
1 of 3

FIGURE 1



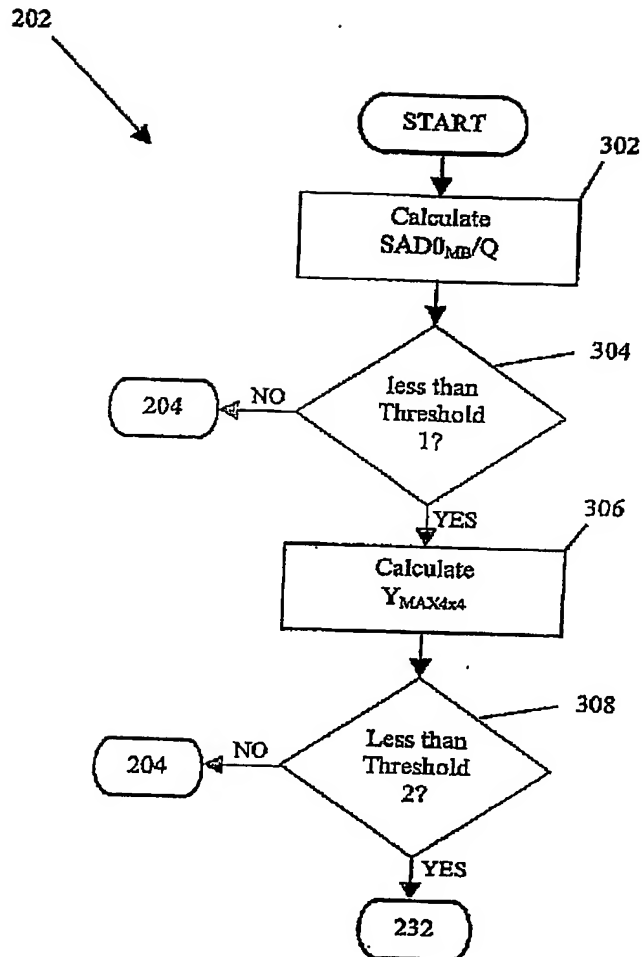
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FIGURE 2



3 of 3

FIGURE 3



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